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"Integrated Wind Turbine Design"

Life cycle analysis of wind turbine materials

Inclusion of LCA data in the materials database

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Abstract: This document provides a description of general LCA material properties in revised test database, coupled to design package for LCA of a rotor blade

Contents

STATUS, CONFIDENTIALITY AND ACCESSIBILITY										
Status				Confidentiality				Accessibility		
S0	Approved/Released			**R0**	General public				Private web site	
S1	Reviewed			**R1**	Restricted to project members				Public web site	
S2	Pending for review			**R2**	Restricted to European. Commission				Paper copy	
S3	Draft for commends			**R3**	Restricted to WP members + PL					
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1. Introduction

This document briefly describes the state-of-the art of rotor blade LCA, information available for life cycle analysis of wind turbine materials, and the procedure for including relevant data in the test database of WMC. This report contributes to UPWIND Deliverable D 3.1.2: "General LCA material properties in OPTIDAT, coupled to design package for LCA of rotor blade" [1].

2. Background

Life cycle analysis is the systematic analysis of the environmental impact of a product throughout its lifecycle. LCA can be applied to any product, and the scope can be very wide.

This report focuses on wind turbine rotor blades, and, more specifically makes an inventory of how LCA data can be included into the WMC test database. Therefore, the focus will be on materials that are likely to be tested, i.e. predominantly glass fibre and epoxy.

LCA data are typically categorised per life cycle. They can be expressed in various formulations. Typically, a distinction is made between:

- Resource consumption
- Emissions
- Waste
- Contribution to global warming
- Toxicity
- Ozone depletion
- …

These various contributions to product environmental impact can, in turn, be expressed in terms of:

- Energy,
- Mass,
- Per capita
- Equivalent CO_2
- …

The impact of abovementioned factors depends on the location where a product is manufactured or used, so the actual impact is often weighed using region-dependent weighting factors.
Obviously, some of the impacts are very difficult to quantify, since they depend on policy, knowledge of the impact, or because they are simply hard to quantify, e.g. visual intrusion.
An important part of LCA (not always included) are external costs or externalities. These are indirect environmental impacts, such as visual intrusion, or even benefits by increased employment. These are particularly difficult to quantify, see e.g. [2].

3. Wind energy and LCA

According to [3] 1 kWh of wind energy avoids 0.68 kg of CO_2 and 0.02 acid equivalent and 0.29m^3 natural gas is saved. In the same report, an ecological recovery-time for the wind turbine of 5 months is reported.
Vestas calculates that the energy required for manufacturing a turbine is equivalent to 6.6 months of operatioun for an onshore turbine and 6.8 months for an offshore turbine [5][4]. In this study, the rotor is modelled as weighing 40 tons.

Around 1998, it was expected that the amount of waste from wind turbine blades would grow from 1,000 tons in 2000, to 14,000 tons in 2015 (but this number was already expected to be an

underestimate in 2002) [3]. Another project estimates an annual decommissioning of 300,000 tonnes of blades by 2040. A poll among experts emphasized, that blades are not only the components of the wind turbine that are the hardest to decommission, but that development of suitable decommissioning techniques is also more important than for other components [4].
According to [6], 50,000 tons of glass fibre-reinforced plastics are produced annually. Only 20% of recycled materials can be used successfully in other products.

Relatively recently, an ISO standard has been updated giving guidelines for performing LCA in general [7][7].

Numerous software tools exist to perform LCA, an inventory can be found in [8].

4. LCA data for rotor blade materials

Given the focus of the WMC test database, the general LCA material properties to be included in the database is the LCA-score, in mPoints/kg according to the Eco-95 indicator scoring system. Values for glass/epoxy are taken from [3]. The order of magnitude is equal to the value given for a glass fibre/epoxy blade in [9]. This may be elaborated in the future to e.g.:

- Energy required during production of fibre, resin, and catalyst
- Energy during production of blade
- Waste resulting from production of fibre, resin, and catalyst
- Waste resulting from manufacturing

Manufacturing process plays an important role in the LCA score of blades. Manufacturing methods differ from manufacturer to manufacturer. Nowadays, most use predominantly closed mould techniques, however obviously not much is published on the details.
Some information is provided by Vestas using pre-preg in their V90 blades. This is glass-fibre pre-impregnated with epoxy resin. They estimate about 10% cutting losses. Of the auxiliary material used (separation film, vacuum fleece including excess resin, vacuum foil, slip and bleeding foil) no quantities are given. In their study, they assume 100% recycling of cutting losses, without credit for avoided production; separation film is included as recyclable material, auxiliary materials are included as combustible with heat recovery following Danish standards.

5. Coupling with FOCUS

In the new LCA Module in the FOCUS rotor blade design package (new version under development), the LCA score of the blade can be calculated. This is done similar to the calculation of blade cost, i.e., the amount of material is multiplied with the material-specific LCA score for each material. The separate material contributions are added to establish the full blade LCA score.
This cost-analogous LCA summation does not include the effect of manufacturing methods and manufacturing location. Therefore, the results should be used as a basis for comparison of blade designs, rather than as an absolute LCA score.

6. References

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